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WEEKLY TRAINING FREQUENCY AS A CORRELATE OF EXECUTIVE FUNCTION IN SPORT SCIENCE STUDENTS

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ABSTRACT

This Pilot study aimed to examine the relationship between weekly training frequency and executive function among sport science students. A correlational, cross-sectional design was employed involving 50 Sport Science students (32 males, 18 females; age M = 19.56, SD = 0.70 years) who were free of neurological disorders and abstained from caffeine for 12 hours prior to testing. Weekly training frequency was self-reported, while executive function was assessed using the Digit Span Test, Stroop Test, and Trail Making Test (TMT). Because several variables were not normally distributed (Shapiro–Wilk test), Spearman's rho correlation was used as the primary analysis, supplemented with Kruskal–Wallis tests across training-frequency categories and Mann–Whitney U tests for sex comparisons. Weekly training frequency showed a significant, strong positive correlation with Stroop Test scores (rho = 0.529; $p < 0.001$), indicating better inhibitory control among students who trained more frequently. Stroop Test scores were also significantly negatively correlated with TMT completion time (rho = −0.402; p = 0.004), Digit Span scores were significantly negatively correlated with TMT time (rho = −0.290; p = 0.041), and Digit Span scores were significantly positively correlated with Stroop Test scores (rho = 0.315; p = 0.026); in other words, all three executive function measures were significantly intercorrelated. Correlations between training frequency and Digit Span (rho = 0.257; p = 0.072) and TMT (rho = −0.171; p = 0.234) were not statistically significant. Weekly training frequency was selectively associated with inhibitory control, but not consistently with working memory or processing speed/cognitive flexibility, among sport science students. These findings support the hypothesis that the cognitive benefits of physical activity are domain-specific and most consistent for tasks demanding high inhibitory control.

Keywords: training frequency; executive function; inhibitory control; working memory; Stroop Test; Trail Making Test; sport science students

Introduction

Executive function refers to a set of higher-order cognitive processes that enable individuals to plan, monitor, and regulate behaviour toward a particular goal. Theoretically, executive function comprises three interrelated yet empirically distinguishable core components: working memory, inhibitory control, and cognitive flexibility, which together form the foundation for more complex cognitive abilities such as reasoning, problem-solving, and planning (Diamond, 2013). These three components play a critical role not only in academic activity but also in sport performance, since athletes and sport practitioners are required to make

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rapid decisions, suppress impulsive responses, and adapt to changing match situations in real time.

This is consistent with the broader recognition that Physical Education, Sports, and Health (PJOK) learning in Indonesia holds strategic potential for cultivating students' cognitive, not merely physical, capacities (Jumarin et al., 2026). Sport science students occupy a unique position in this context: on the one hand, they are young adults at the peak of their cognitive and physiological capacity, and on the other hand, they are routinely exposed to physical activity and sport training as part of both their curriculum and lifestyle. This condition makes the sport science student population particularly relevant for examining the relationship between physical training frequency and executive function, given the relatively wide variation in training frequency among them, ranging from two sessions per week to more than five sessions per week.

A number of recent systematic reviews and meta-analyses have consistently reported that physical activity is positively associated with executive function across various age groups, including adolescents and young adults (S. Liu et al., 2020). Among college students in China, training intensity and duration have been shown to improve both the accuracy and speed of responses on working memory, inhibitory control, and cognitive flexibility tasks, with training intensity exerting a larger effect than duration (Yu et al., 2023).

Of the three components of executive function, inhibitory control is the component most frequently investigated in the context of sport and physical activity. The Stroop Test, which measures an individual's ability to suppress an automatic response in favour of task-relevant information, is widely used as an indicator of inhibitory control (Predovan et al., 2012). Evidence from randomized controlled trials shows that 12 weeks of cardiovascular exercise improves inhibitory control in previously sedentary young adults (Remiszewski et al., 2025), while a 9-week intervention study among 18–20-year-olds found an association between aerobic fitness and white matter integrity with implications for inhibitory control (Zhu et al., 2021). Acute effects of high-intensity exercise on Stroop performance have also been reported among physical education and sport science students, as has comparable improvement following both low-intensity resistance exercise with slow movement and high-intensity resistance exercise (Sugimoto et al., 2020). At the neurophysiological level, a single bout of physical activity also modulates frontal beta-oscillation activity linked to executive function in sedentary youth (Lv et al., 2024), consistent with the behavioural gains reported above. Together, these acute and short-term studies converge on inhibitory control as the component most consistently responsive to physical activity, regardless of exercise modality, differing mainly in exposure duration and the marker used to index the effect.

The working memory component, commonly measured using the Digit Span task, has also been linked to physical activity level, although the available evidence tends to be more mixed than that for inhibitory control. A recent meta-analysis of 21 studies involving 1,455 participants found a small but significant advantage in working memory for athletes compared with non-athletes (Hedges' $g = 0.30$), with a larger advantage when athletes were compared with a sedentary reference group ($g = 0.63$) (Wu et al., 2025). However, a study among medical students at Universitas Sumatera Utara found no significant correlation between physical activity and working memory capacity (Nadira & Daulay, 2022), and a study of collegiate athletes versus non-athletes showed that the relationship between sport participation and working memory could vary by sex and by sport type (Lineweaver et al., 2020). Exercise type itself may also matter: a comparison of different training modalities found that their effects on working memory were not uniform, with some modalities yielding clearer benefits than others (Gonzalez & Kochen, 2024). The relatively low cognitive demand of the Digit Span task, compared with other working memory tasks such as the n-back, has been suggested as one possible explanation for the inconsistency of findings in this domain. Overall, unlike the fairly convergent evidence for inhibitory control, working-memory findings remain mixed across population, exercise type, and outcome sensitivity.

The third component, cognitive flexibility and processing speed, is commonly measured using the Trail Making Test (TMT), particularly Part B, which requires cognitive set-shifting between number and letter sequences (Tsiakiri et al., 2024). The TMT is widely used in clinical neuropsychology owing to its sensitivity to cognitive impairment, but its application among healthy, physically active young adults, particularly sport science students, remains relatively limited. Because the TMT is scored based on completion time in seconds, better performance is represented by a shorter completion time.

Mechanistically, the relationship between physical activity and executive function is explained through several neurobiological pathways. The cardiorespiratory fitness hypothesis posits that improved cardiorespiratory fitness through regular physical training increases cerebral blood flow and oxygenation in the prefrontal cortex, a region central to cognitive control including response inhibition (Mekari et al., 2022), consistent with evidence that cardiorespiratory (but not muscular) fitness is significantly associated with cognitive control in late adolescents (Shigeta et al., 2021). A correlational study among Indonesian secondary school students similarly reported that fitness level was significantly related to cognitive assessment outcomes (Hidayati et al., 2026), reinforcing this link within the Indonesian educational context. A second pathway involves brain-derived neurotrophic factor (BDNF), a neurotrophin involved in neuroplasticity, hippocampal neurogenesis, and synaptic connectivity in the prefrontal cortex (Ronca et al., 2026);(de Assis & Almondes, 2017);(Tutakhail et al., 2025); aerobic exercise increases serum BDNF both acutely and following medium-term training, with these increases associated with improved executive function (Birinci et al., 2026). The two pathways are complementary: the former reflects rapid, activity-related changes in cerebral blood flow, the latter more gradual neuroplastic adaptation, both converging on the prefrontal cortex as the shared substrate for the inhibitory control gains reported above.

Although evidence for the cognitive benefits of physical activity continues to grow, the literature reviewed above reveals three recurring gaps. First, most prior studies focus on a single executive function component rather than assessing working memory, inhibitory control, and cognitive flexibility together (e.g., (Sugimoto et al., 2020), on inhibitory control alone). Second, many rely on short-term intervention designs in previously sedentary, non-athlete populations

(Remiszewski et al., 2025); (Zhu et al., 2021) rather than habitual training frequency among individuals already routinely active. Third, much of the evidence comes from children and adolescents (Hillman et al., 2020); (Altamimi et al., 2025) or older adults (Yang et al., 2026), leaving young, physically active adults comparatively understudied. To our knowledge, no published study has simultaneously (a) used weekly training frequency as the primary activity indicator, (b) measured all three executive function components in the same sample, and (c) done so among sport science students in Indonesia — a population in which training exposure is naturally embedded in daily curriculum and lifestyle, offering an ecologically valid setting without an artificial intervention. Existing Indonesian research linking physical activity to cognition and academic achievement has so far treated both as general, undifferentiated constructs rather than decomposing training frequency and executive function into their specific components (Runesi et al., 2024), which is precisely the gap addressed here. Control variables such as caffeine consumption are also rarely reported explicitly, despite being a known confounder (McLellan et al., 2016);(James, 2014).

Based on this gap, the present study aimed to: (1) describe the profile of weekly training frequency and executive function performance (Digit Span, Stroop Test, and TMT) among sport science students; (2) examine the relationship between weekly training frequency and each component of executive function; and (3) explore the interrelations among the components of executive function themselves. It was hypothesized that higher weekly training frequency would be associated with better executive function performance, with the strength of the relationship expected to vary across components, consistent with the notion that the cognitive benefits of physical activity are domain-specific (L. Liu et al., 2025); (Verburgh et al., 2014).

Methods

This study employed a correlational design with a cross-sectional approach to examine the relationship between weekly training frequency and executive function performance. The correlational design was chosen given the exploratory-descriptive aim of the study, namely to map the pattern of association among variables under naturalistic conditions without experimental manipulation, as is common in preliminary studies preceding controlled intervention trials (Lineweaver et al., 2020); (Pluncevic-Gligoroska et al., 2010).

Participants were active undergraduate students enrolled in the Sport Science study program at Universitas Pendidikan Indonesia, recruited using a convenience sampling technique. After the screening process, complete and valid data were obtained from 50 students (32 males, 64.0%; 18 females, 36.0%) with a mean age of 19.56 years (SD = 0.70; range 19–22 years). Inclusion criteria were: (1) active enrolment as a Sport Science student; (2) no history of neurological disorders that could affect cognitive performance; and (3) voluntary participation with signed informed consent. As a control for potential pharmacological confounding, all participants were required to abstain from caffeinated beverages and food for 12 hours prior to cognitive testing, given that caffeine can affect attention and information-processing speed through adenosine mechanisms (McLellan et al., 2016);(James, 2014). All participants in the final sample met this criterion (Table 1).

Data were collected in a single standardized testing session for each participant. Prior to testing, participants received an explanation of the study's purpose and testing procedures, followed by completion of demographic data (age, sex), confirmation of the absence of neurological disorders, and confirmation of compliance with the 12-hour caffeine abstinence instruction. Participants then completed a series of cognitive tasks (Digit Span, Stroop Test, and TMT) in sequence under the supervision of the research team in a quiet, distraction-free room. Weekly training frequency data were obtained through a brief structured interview administered after the cognitive testing session.

Weekly training frequency was obtained through self-report regarding the number of structured physical training sessions completed by participants within one week, ranging from 2 to 7 sessions per week in this sample.

Working memory was assessed using the Digit Span task, a standard neuropsychological task that requires participants to recall and repeat sequences of digits of progressively increasing length. The reported score represents the maximum digit span correctly recalled, such that a higher score indicates better working memory capacity (Lineweaver et al., 2020);(Pluncevic-Gligoroska et al., 2010);(Organization, 2020).

Inhibitory control was assessed using the Stroop Test, which requires participants to name the ink colour of a printed word while ignoring the meaning of the word itself when word and colour are incongruent. The Stroop score used in this study represents the number of correct responses achieved, such that a higher score reflects better inhibitory control (Sugimoto et al., 2020);(Predovan et al., 2012).

Cognitive flexibility and processing speed were assessed using the Trail Making Test (TMT), which requires participants to connect a series of numbered circles as quickly and accurately as possible. The reported TMT score is the completion time in seconds, such that a lower score (shorter time) reflects better processing speed and cognitive flexibility, consistent with standard TMT scoring conventions in the neuropsychological literature (Tsiakiri et al., 2024).

Data were analysed using Python (SciPy, pandas, and scikit-posthocs). Descriptive statistics (mean, standard deviation, median, and range) were computed for all variables. The Shapiro–Wilk normality test was applied to training frequency, Digit Span, Stroop Test, and TMT to determine the appropriate correlation technique. Because the results indicated that training frequency, Digit Span, and TMT deviated significantly from normality ($p < 0.05$), while the Stroop score was relatively close to normal, Spearman's rho correlation was used as the primary analysis for all variable pairs to maintain methodological consistency and accommodate potential non-linear relationships or outliers (Tsiakiri et al., 2024; Sanders et al., 2019). Pearson correlation was additionally reported as a sensitivity analysis. For further exploration, participants were grouped into three training-frequency categories (low: ≤2 sessions/week; moderate: 3–4 sessions/week; high: ≥5 sessions/week) and compared using the Kruskal–Wallis test, with Dunn's post-hoc test (Bonferroni-corrected for pairwise comparisons) applied to any significant omnibus result to identify which specific categories differed. Comparisons of executive function performance between male and female students were conducted using the Mann–Whitney U test. Statistical significance was set at α = 0.05 for all analyses. Correlation strength was interpreted according to Cohen's convention, namely |r| < 0.10 negligible, 0.10–0.29 weak, 0.30–0.49 moderate, and ≥0.50 strong. A post-hoc power calculation indicated that, with N = 50, α = .05 (two-tailed), the study had 80% power to detect a correlation of approximately |r| ≥ .39, meaning the design was adequately powered to detect moderate-to-strong associations but underpowered for small effects (|r| < .30); this is consistent with the two correlations that approached but did not reach significance in this sample (training frequency–Digit Span, p = 0.072; training frequency–TMT, p = 0.234). Because a total of 13 significance tests were conducted across the correlation, Kruskal–Wallis, and Mann–Whitney U analyses, a Bonferroni-corrected alpha ($\alpha_{corrected}$ = 0.05/13 ≈ 0.0038) was additionally applied as a conservative check against Type I error inflation, and findings are reported both at the conventional α = .05 threshold and with reference to this corrected threshold.

This study was reviewed and approved by the Research Ethics Committee of Universitas Pendidikan Indonesia (Ethical Approval No. 144/UN40.K/PT.01.01/2026; approval date: April 30, 2026). All research procedures were conducted in accordance with the ethical principles for research involving human participants.

Results

Table 1 presents the demographic characteristics and descriptive statistics of the study variables for the 50 participants. The mean age of participants was 19.56 years (SD = 0.70), with the majority aged 19 years (54.0%). The sex composition was predominantly male (64.0%) compared with female (36.0%). The mean weekly training frequency was 3.44 sessions per week (SD = 1.67; range 2–7 sessions), with a median of 3 sessions per week.

Table 1. Demographic Characteristics and Descriptive Statistics of Study Variables (N = 50)

Variable	n (%) / Median (Min–Max)	M ± SD
Age (years)	19.56 (19–22)	19.56 ± 0.70
Sex — Male	32 (64.0%)	—
Sex — Female	18 (36.0%)	—
Training frequency (sessions/week)	3.0 (2–7)	3.44 ± 1.67
Digit Span score	4.0 (3–7)	4.44 ± 0.91
Stroop Test score	53.0 (20–101)	53.74 ± 16.51
TMT time (seconds)	81.0 (54–158)	87.30 ± 23.37

Note: M = mean; SD = standard deviation. Because the Shapiro–Wilk test (below) indicated that training frequency, Digit Span, and TMT deviated significantly from normality, the median (min–max) is reported as the primary descriptive statistic for these variables, consistent with the non-parametric (Spearman) analysis used; the Stroop Test score, which did not deviate significantly from normality, is best summarised by the mean ± SD. Both statistics are retained here for completeness and comparability with Table 3.

All participants (100%) reported no caffeine consumption within 12 hours prior to testing and no history of neurological disorders; consequently, these two variables did not vary and were not included in further correlation analyses.

The Shapiro–Wilk test indicated that training frequency ($W = 0.791$; $p < 0.001$), Digit Span ($W = 0.878$; $p < 0.001$), and TMT ($W = 0.901$; $p = 0.001$) deviated significantly from a normal distribution, whereas the Stroop Test score was relatively close to normal ($W = 0.982$; $p = 0.641$). Given that three of the four main variables were not normally distributed, Spearman's rho correlation was used as the primary correlation analysis for all variable pairs.

Table 2 presents the Spearman correlation matrix between weekly training frequency and the three executive function indicators, along with the inter-correlations among indicators. Weekly training frequency showed a strong, statistically significant positive correlation with Stroop Test scores (rho = 0.529; $p < 0.001$), indicating that students with higher training frequency tended to exhibit better inhibitory control. In contrast, the correlation between training frequency and Digit Span score was positive but weak to moderate and did not reach statistical significance (rho = 0.257; $p = 0.072$), and likewise the correlation between training frequency and TMT time was weakly negative and non-significant (rho = −0.171; $p = 0.234$).

Regarding inter-correlations among executive function components, Digit Span scores were significantly positively correlated with Stroop Test scores (rho = 0.315; $p = 0.026$) and significantly negatively correlated with TMT time (rho = −0.290; $p = 0.041$). Stroop Test scores were also significantly negatively correlated with TMT time (rho = −0.402; $p = 0.004$). This pattern is consistent with the scoring direction of each instrument, in that higher Digit Span and Stroop scores (better performance) were associated with shorter TMT completion times (better performance), indicating internal coherence among the executive function measures employed. When the Bonferroni-corrected threshold ($\alpha_{corrected} \approx 0.0038$; see Data analysis) is applied instead of the conventional $\alpha = .05$, only the training frequency–Stroop Test correlation ($p < .001$) remains statistically significant; the Digit Span–Stroop ($p = .026$), Digit Span–TMT ($p = .041$), and Stroop–TMT ($p = .004$) inter-correlations no longer meet this more conservative threshold, although the Stroop–TMT correlation falls only marginally short of it. These secondary inter-correlations are therefore reported descriptively and should be interpreted with appropriate caution.

Table 2. Spearman Correlation Matrix between Training Frequency and Executive Function Components (N = 50)

Variable	1	2	3	4
1. Training Frequency	—	0.257	0.529**	−0.171
2. Digit Span		—	0.315*	−0.290*
3. Stroop Test			—	−0.402**
4. TMT (seconds)				—

Note: Values are Spearman's rho correlation coefficients. *p < 0.05; **p < 0.01.

As a sensitivity analysis, Pearson correlations showed a similar pattern of direction and significance: training frequency with Stroop (r = 0.536; p < 0.001), training frequency with Digit Span (r = 0.153; p = 0.290, not significant), training frequency with TMT (r = −0.191; p = 0.184, not significant), Digit Span with Stroop (r = 0.343; p = 0.015), Digit Span with TMT (r = −0.186; p = 0.195, not significant under Pearson though significant under Spearman), and Stroop with TMT (r = −0.393; p = 0.005). The direction and magnitude of the training frequency–Stroop correlation, the study's main finding, were consistent across both methods, strengthening confidence in that specific result. However, this consistency was not universal: the Digit Span–TMT correlation was significant under Spearman (rho = −0.290; p = 0.041) but not under Pearson (r = −0.186; p = 0.195), indicating that this particular inter-correlation is sensitive to the choice of analytic method and should be interpreted more cautiously than the main training-frequency–Stroop finding.

Figure 1 presents a heatmap of the Spearman correlation matrix to visualize the strength and direction of relationships among all variables, while Figure 2 displays scatter plots with regression lines for the four statistically significant variable pairs: training frequency–Stroop Test, Digit Span–Stroop Test, Digit Span–TMT, and Stroop Test–TMT (Table 2). The two non-significant pairs (training frequency–Digit Span and training frequency–TMT) are omitted from Figure 2 but are reported numerically in Table 2.

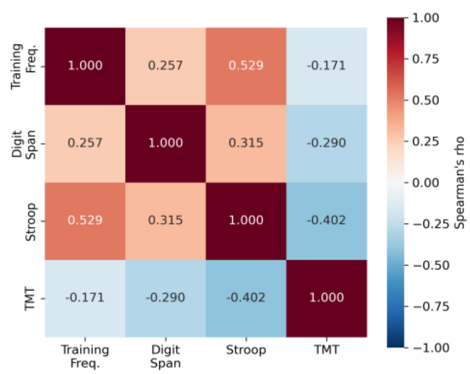

Figure 1. Heatmap of the Spearman Correlation Matrix between Weekly Training Frequency and Executive Function Components

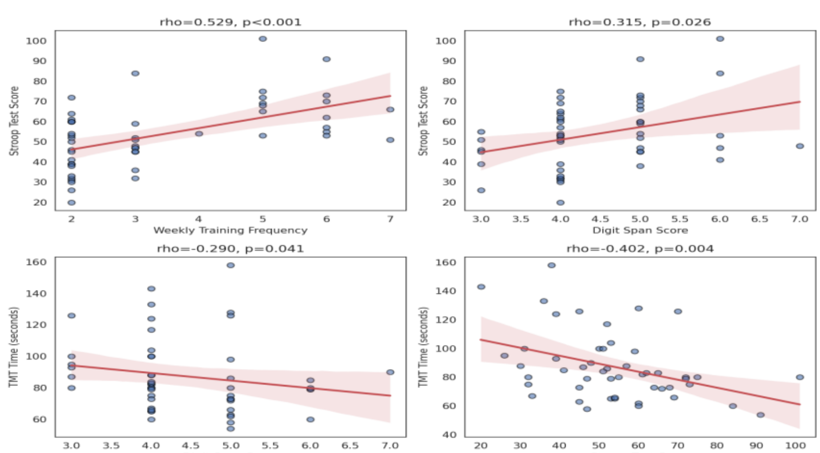

Figure 2. Scatter Plots of the Four Statistically Significant Relationships: Weekly Training Frequency and Stroop Test Score, Digit Span and Stroop Test Score, Digit Span and TMT Time, and Stroop Test Score and TMT Time (N = 50).

To further explore the pattern of relationships in a more intuitive manner, participants were grouped into three training-frequency categories: low (≤2 sessions/week, n = 22), moderate (3–4 sessions/week, n = 12), and high (≥5 sessions/week, n = 16). Table 3 and Figure 3 show that the mean Stroop Test score increased progressively across training-frequency categories (low: 45.73 ± 13.95; moderate: 50.00 ± 12.97; high: 67.56 ± 13.63), and this difference was statistically significant based on the Kruskal–Wallis test (H = 18.34; $p < 0.001$). Mean Digit Span scores also differed significantly across categories (H = 6.79; p = 0.033), although this did not survive the Bonferroni-corrected threshold ($\alpha_{corrected} \approx 0.0038$) applied across all 13 tests, and the pattern of increase was not as linear as for Stroop scores—the moderate category showed the highest mean (4.92 ± 1.08), followed by the high (4.56 ± 0.81) and low (4.09 ± 0.75) categories. In contrast, mean TMT time did not differ significantly across training-frequency categories (H = 1.90; p = 0.386), although the direction of the difference consistently showed shorter times in higher training-frequency categories (low: 93.00 ± 27.13 seconds; moderate: 84.33 ± 23.78 seconds; high: 81.69 ± 15.82 seconds). To localise these omnibus effects, Dunn's post-hoc test with Bonferroni correction was conducted for the two significant Kruskal–Wallis comparisons. For Stroop Test scores, the high-frequency category scored significantly higher than both the low-frequency ($p < 0.001$) and moderate-frequency (p = 0.005) categories, while low and moderate did not differ significantly from each other (p = 1.000); this indicates that the overall Stroop difference was driven specifically by the high-frequency group rather than a smooth linear increase across all three categories. For Digit Span scores, the moderate-frequency category scored significantly higher than the low-frequency category (p = 0.041), whereas neither the high-frequency category compared with low (p = 0.255) nor the high compared with moderate category (p = 1.000) reached significance.

Table 3. Executive Function Performance by Weekly Training Frequency Category

Training Frequency & Category	n	Digit Span (M ± SD)	Stroop Test (M ± SD)	TMT seconds (M ± SD)
Low (≤2x/week)	22	4.09 ± 0.75	45.73 ± 13.95	93.00 ± 27.13
Moderate (3–4x/week)	12	4.92 ± 1.08	50.00 ± 12.97	84.33 ± 23.78
High (≥5x/week)	16	4.56 ± 0.81	67.56 ± 13.63	81.69 ± 15.82

Note: M = mean; SD = standard deviation. Kruskal–Wallis test: Digit Span H = 6.79, p = 0.033; Stroop Test H = 18.34, $p < 0.001$; TMT H = 1.90, p = 0.386. Dunn's post-hoc (Bonferroni-corrected): Digit Span, low vs. moderate p = 0.041 (low vs. high p = 0.255; moderate vs. high p = 1.000); Stroop Test, low vs. high $p < 0.001$, moderate vs. high p = 0.005 (low vs. moderate p = 1.000).

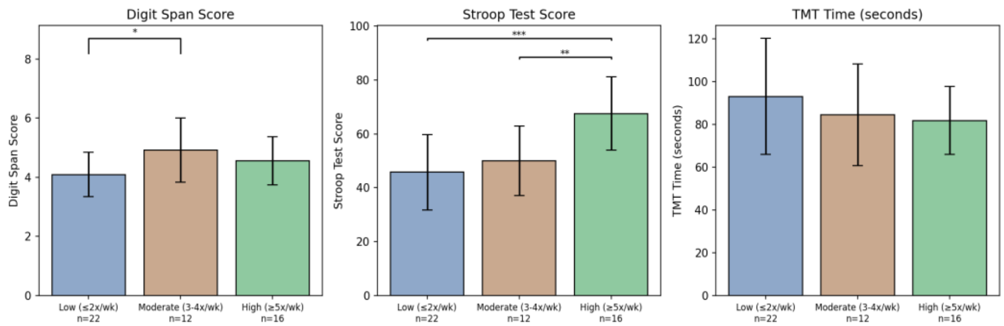

Figure 3. Mean Digit Span Score, Stroop Test Score, and TMT Time by Weekly Training Frequency Category (Error Bars = Standard Deviation). Brackets denote Dunn's post-hoc pairwise comparisons that remained significant after Bonferroni correction (* $p < .05$; ** $p < .01$; *** $p < .001$); see Table 3 note for exact values.

The Mann–Whitney U test indicated no significant differences between male and female students in weekly training frequency (male: 3.53 ± 1.65; female: 3.28 ± 1.74; U = 326.5; p = 0.418), Digit Span score (male: 4.50 ± 0.95; female: 4.33 ± 0.84; U = 304.5; p = 0.729), Stroop Test score (male: 54.56 ± 17.71; female: 52.28 ± 14.50; U = 300.0; p = 0.816), or TMT time (male: 89.78 ± 25.56 seconds; female: 82.89 ± 18.72 seconds; U = 329.5; p = 0.407). These findings indicate that the relationship between training frequency and executive function observed in this sample was relatively consistent across sexes and was not influenced by significant gender differences.

Discussion

This study aimed to examine the relationship between weekly training frequency and three core components of executive function, namely working memory, inhibitory control, and cognitive flexibility/processing speed, among sport science students. The main finding indicates that weekly training frequency was selectively associated with executive function, with a strong and consistent association observed for inhibitory control (Stroop Test score), but not for working memory (Digit Span) or processing speed/cognitive flexibility (TMT).

The strong positive correlation between weekly training frequency and Stroop Test score (rho = 0.529; p < 0.001) represents the most robust finding of this study and is consistent with the existing literature. This result aligns with a randomized controlled trial showing that 12 weeks of cardiovascular exercise improved inhibitory control in sedentary young adults, marked by reduced cognitive conflict on both electrophysiological and behavioural indicators (Remiszewski et al., 2025). A study among physical education and sport science students in Colombia also reported that high-intensity exercise sessions conferred beneficial effects on inhibitory control as measured by the Stroop Test (Zhu et al., 2021), while a study on resistance training, both low-intensity with slow movement and high-intensity, showed comparable improvements in inhibitory control (Sugimoto et al., 2020). The consistency of findings across exercise modalities reinforces the notion that inhibitory control is the executive function component most responsive to physical activity (Carbonell-Hernandez et al., 2022). A plausible explanation is that response inhibition is the executive skill most directly rehearsed during sport training itself: athletes must continuously suppress prepotent motor responses to react to opponents and changing match conditions, functioning as recurring, ecologically embedded practice. This may explain why the Stroop association was stronger and more consistent across analytic methods than the associations with Digit Span or TMT, which are less directly rehearsed by sport-specific demands, and suggests that the cognitive benefits of exercise may partly reflect the overlap between a sport's cognitive demands and the executive function component being measured.

Theoretically, as outlined in the Introduction, this relationship is consistent with both the cardiorespiratory fitness hypothesis (increased cerebral blood flow and oxygenation in the prefrontal cortex; (Shigeta et al., 2021); (Hidayati et al., 2026) and the BDNF neurotrophic pathway (de Assis & Almondes, 2017), both of which converge on the prefrontal cortex as the shared substrate for response inhibition.

The increase in Stroop score across training-frequency categories (Table 3, Figure 3) provides descriptive support for a dose-response pattern, although Dunn's post-hoc test indicates this is better characterised as a threshold effect than a smooth linear increase: the high-frequency category (≥5 sessions/week) scored significantly higher than both the low ($p < 0.001$) and moderate ($p = 0.005$) categories, whereas low and moderate did not differ from each other ($p = 1.000$). In other words, a clear cognitive advantage was only detectable once training frequency reached five or more sessions per week, rather than accruing incrementally from two to four sessions. The cross-sectional design of this study does not permit causal conclusions regarding this apparent threshold. This finding is broadly consistent with a dose-response meta-analysis among children that found a significant linear association between training frequency and effect size on executive function (Wang et al., 2025), although among older adults the dose-response relationship tends to be more complex and not always linear (Sanders et al., 2019); the present threshold-like pattern adds sport science students as a population in which the dose-response curve may not be strictly linear either.

In contrast to inhibitory control, the correlation between weekly training frequency and Digit Span score did not reach statistical significance in this study (rho = 0.257; $p = 0.072$), although the direction of the relationship remained positive. This finding is consistent with a recent meta-analysis showing that, because of its relatively lower cognitive demand compared with other working memory tasks such as the n-back, the Digit Span task tends to be less sensitive in detecting the cognitive benefits of physical activity or sport expertise (Verburgh et al., 2014). A study among medical students at Universitas Sumatera Utara even found no significant correlation at all between physical activity and working memory capacity, while a study of collegiate athletes found that the relationship between sport participation and auditory working memory varied by sex and by sport type (team versus individual); indeed, among males, infrequent exercisers showed an advantage in visual working memory over athletes (Lineweaver et al., 2020).

Nevertheless, the categorical exploration in this study (Table 3) revealed an interesting pattern: the highest Digit Span score was found in the moderate training-frequency category (3–4 sessions/week), rather than the highest category (≥5 sessions/week). Dunn's post-hoc test clarifies this pattern: the moderate category scored significantly higher than the low category ($p = 0.041$, Bonferroni-corrected), but did not differ significantly from the high category ($p = 1.000$), and the high category did not differ significantly from the low category either ($p = 0.255$). In other words, the data support a genuine step-up in Digit Span performance from low to moderate training frequency, but do not provide statistically robust evidence that scores subsequently decline at the highest frequency category, since high could not be statistically distinguished from either moderate or low. The descriptive "dip" at the high-frequency category should therefore be interpreted cautiously, particularly given that the moderate category comprised only 12 participants; a classic inverted-U/overtraining-fatigue explanation (whereby excessive training without adequate recovery impairs cognitive performance) remains a plausible hypothesis consistent with the descriptive means (Yu et al., 2023), but it is not the only explanation statistically supported by these data, and it requires replication in a larger, more balanced sample with more comprehensive training-load measures (intensity and duration, not frequency alone) before it can be considered confirmed. This result differs from a study among healthy young adults in North Macedonia, which reported a consistent upward trend in both forward and backward Digit Span scores with increasing long-term physical activity level, from sedentary to recreationally active to athlete groups (Pluncevic-Gligoroska et al., 2010), suggesting that the relationship between physical activity and working memory is likely moderated by population characteristics, duration of physical activity exposure, and the measurement instrument used.

The correlation between weekly training frequency and TMT completion time was non-significant ($rho = -0.171$; $p = 0.234$), though negative as expected. The TMT engages a complex cognitive network spanning visual processing speed, visual tracking, and cognitive flexibility simultaneously (Tsiakiri et al., 2024); (Verburgh et al., 2014), which may render it less sensitive to training frequency than a more purely inhibition-based task like the Stroop Test; this is consistent with literature noting that physical activity effects on shifting tasks are less consistent than effects on inhibition (Nadira & Daulay, 2022). Nevertheless, the significant negative correlations between TMT time and both Digit Span ($rho = -0.290$; $p = 0.041$) and Stroop score ($rho = -0.402$; $p = 0.004$) indicate that TMT performance remained internally coherent with the other executive function measures, consistent with the unity/diversity model (Diamond, 2013): students with better inhibitory control and working memory also completed the TMT faster, even though this did not translate into a significant link with training frequency itself.

No significant sex differences emerged on any study variable, a relevant finding given mixed literature on sex differences in executive function; neuroimaging studies report differing neural networks between males and females that do not always manifest behaviourally (Gaillard et al., 2021). This may reflect that, in a sport science population relatively homogeneous in physical activity exposure, individual variability in executive function is better explained by training frequency than by sex, supporting the generality of the training frequency–inhibitory control relationship across the sample.

Practically, these findings carry three implications for students, educators, and coaches. First, the threshold-like advantage in inhibitory control observed at ≥5 sessions/week suggests that maintaining a high weekly training frequency may support cognitive control relevant to rapid decision-making in both sport and academic contexts; because only frequency, not duration or intensity, was measured here, this cannot yet be translated into WHO minutes/intensity recommendations (Organization, 2020) without further research. Second, because working memory and cognitive flexibility were not consistently related to frequency alone, improving these domains may require more targeted approaches, such as cognitively engaging exercise that combines cognitive and motor demands, which has shown larger effects on cognitive flexibility than conventional aerobic exercise (L. Liu et al., 2025). Third, controlling for confounders such as caffeine intake and neurological history, as done here, should become standard practice in similar research.

Conclusion

This correlational study provides evidence that weekly training frequency among sport science students was selectively associated with components of executive function. A strong and significant relationship was found between training frequency and inhibitory control (Stroop Test score; rho = 0.529; $p < 0.001$), whereas the relationships with working memory (Digit Span) and cognitive flexibility/processing speed (TMT) were not statistically significant, although both showed directions consistent with the study hypothesis. Significant inter-correlations among executive function components indicate coherence of the underlying constructs measured. No significant differences were found between male and female students on any study variable. These findings reinforce the evidence that the cognitive benefits of physical activity are domain-specific, with inhibitory control representing the component most consistently associated with training frequency, and provide an empirical basis for developing training programs that consider not only the physical but also the cognitive benefits for sport science students.

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